
Polystichum tiankengicola (Dryopteridaceae), a New Species from a Karst Sinkhole from Guizhou, China

Qiang Luo

School of Geography & Life Sciences, Bijie University, Bijie, Guizhou 551700,
People's Republic of China

Li-Bing Zhang*

Missouri Botanical Garden, P.O. Box 299, St. Louis, Missouri 63166-0299, U.S.A., and Chengdu
Institute of Biology, Chinese Academy of Sciences, P.O. Box 416, Chengdu, Sichuan 610041,
People's Republic of China.

*Corresponding author: libing.zhang@mobot.org

ABSTRACT. A new pteridophyte species, *Polystichum tiankengicola* Li Bing Zhang, Q. Luo & P. S. Wang (Dryopteridaceae), is described and illustrated from a high-elevational karst sinkhole from Guizhou Province in China. Morphological evidence suggests that *P. tiankengicola* is a member of series *Basigemmifera* W. M. Chu & Z. R. He in section *Micropolystichum* Daigobo, based on the presence of bulbils on rachis and the small habit. *Polystichum tiankengicola* is unique in series *Basigemmifera* in having a bulbil at both the base and apex of the rachis. Morphologically, the new species is most similar to *P. capillipes* (Baker) Diels, also of series *Basigemmifera*, but beyond the distinctive number of bulbils on the rachis, *P. tiankengicola* has a truncate lamina apex and its perispores have an echinate sculpture with irregular ridges, in contrast to *P. capillipes*, which has only one bulbil at the base of the rachis, an acuminate lamina apex, and perispores that have a granular sculpture. *Polystichum tiankengicola* is found only from the highest elevational, karst sinkhole known in China (2530 m) and is considered to be Critically Endangered (CR), based on IUCN Red List criteria.

Key words: Alpine flora, China, Dryopteridaceae, Guizhou, IUCN Red List, karst sinkhole, *Polystichum*.

The Jiucaiping, or the Leek Terrace, ca. 26°51'6.516"N, 104°41'34.26"E, was so named because of the common occurrence of *Allium wall-ichii* Kunth (Amaryllidaceae) toward the summit of the mountain. The site is located at the junction of Hezhang, Shuicheng, and Weining counties in northwestern Guizhou. As the highest peak in Guizhou Province, China, with an elevation of 2906 m, Jiucaiping is richly diverse in its fern flora. In recent years, a number of new fern species have been

discovered from Jiucaiping and neighboring regions, including *Cystopteris guizhouensis* X. Y. Wang & P. S. Wang (Wang & Wang, 1997a), *Dryopteris hezhangensis* P. S. Wang (Wang & Wang, 2001), *Polystichum jiucaipingense* P. S. Wang & Q. Luo (Luo, 2009), *P. nayongense* P. S. Wang & X. Y. Wang (Wang & Wang, 1997b), and *P. puteicola* Li Bing Zhang, H. He & Q. Luo (Zhang et al., 2010). Recently, Wang and Wang (1991, 1994, 1997b, 2001) further documented quite a number of fern species new to Guizhou from this area, e.g., *Aleuritopteris veitchii* (Christ) Ching, *Athyrium biserulatum* Christ, *A. filix-femina* (L.) Roth, *Cystopteris moupinensis* Franch., *Dryopteris nyingchiensis* Ching, *D. thibetica* (Franch.) C. Chr., *Gymnopteris delavayi* (Baker) Underw., *Lepisorus papakensis* (Masam.) Ching & Y. X. Ling, *Leptolepidium dalhousiae* (Hook.) K. H. Shing & S. K. Wu, *Polystichum brachypterum* (Kunze) Ching, *P. cyclolobum* C. Chr., and *P. tsus-simense* (Hook.) J. Sm. var. *mayebarae* (Tagawa) Sa. Kurata. In 2008, field exploration of Jiucaiping revealed a new species of *Polystichum* Roth found at the highest elevational, karst sinkhole in China (2530 m, in the Luobu Stone Forest), which might be the highest such sinkhole documented in the world. The new species is unique in the genus with its proliferous bulbil at both the base and apex of the rachis and is described herein.

Polystichum tiankengicola Li Bing Zhang, Q. Luo & P. S. Wang, sp. nov. TYPE: China. Guizhou: Hezhang Co., Zhushi Yi Autonomous Xiang, Luobu Stone Forest Sinkhole, 26°49'17.76"N, 104°44'8.19''E, among crevices, 2530 m, 12 Mar. 2009, Q. Luo 08380 (holotype, CDBI; isotypes, BJ, MO, Herbarium Pei-Shan Wang [Guizhou Institute of Biology]). Figures 1, 2.

Haec species *Polysticho capillipedi* (Baker) Diels affinis, sed rhachidi bulbilis duobus (vs. bulbilo unico in *P. capillipedi*) instructa, lamina apice truncata (vs. acuminata) atque perisporarum sculptura echinata irregulariter cristata (vs. granulata) differt.

Plants perennial, summer-green, caespitose, 7–22 cm tall; rhizome ca. 1 cm, ascending; sparsely or densely covered with scales; scales linear, brown, ca. 0.1 mm; roots dark brown when dry, to 12 cm, ca. 0.3 mm diam. Leaves 5 to 10 per rhizome; petiole 3–9 cm, 0.3–0.9 mm diam. at mid-portion, adaxially canaliculate, green; basal petiole scales lanceolate, $1.2\text{--}3.5 \times 0.1\text{--}0.8$ mm, chartaceous or membranous, composed of multiple cell layers, brown, margin minutely ciliate (microhairs not evident in Fig. 1D), apex long-caudate, matte; distal petiole scales lanceolate, $1.0\text{--}2.8 \times 0.1\text{--}0.3$ mm, differing in size, composed of 1 or 2 cell layers, membranous, brown, margin long-ciliate, apex long-caudate, matte. Leaf lamina lanceolate, slightly contracted toward base, 1-pinnate, $8\text{--}14 \times 1.6\text{--}2.4$ cm wide at mid-portion, at widest portion 1.8–2.7 cm near the lamina base, apex truncate; rachis 0.2–0.5 mm diam. at mid-portion, adaxially sulcate, with two proliferous bulbils, one each at both the base and apex of the rachis, sometimes only one bulbil at either base or apex, rarely without bulbils; scales of rachis similar to distal petiole scales but smaller, variable in size, chartaceous, brown, margin minutely ciliate (microhairs not evident in Fig. 1E), apex caudate, matte; pinnae in 13 to 22 pairs, not overlapping, slightly pointing upward, basal 2 pairs 0.5–1.2 cm apart, alternate but nearly opposite at leaf base, deltoid in lower portion of leaf blade, oblong in upper portion of leaf blade, middle pinnae $0.9\text{--}1.2 \times 0.5\text{--}0.7$ cm, largest pinnae in lower half of blade, shortly petiolulate, chartaceous, asymmetrical at base, bipinnatifid; lobes in 2 or 3 pairs per pinna, alternate, elliptic or oblong, apex acute, basalmost pairs of lobes free or almost free, scaly abaxially and adaxially; microscales on abaxial surface subulate without dilated base (narrow-type microscales), 0.9–2.25 mm, base ca. 0.1 mm wide, with a few curly cilia on the basal margin; venation pinnate; midrib slightly raised abaxially, flat adaxially. Sori terminal on veinlets, the entire abaxial leaf blade fertile, 2 to 5 sori per pinna, close to midrib, center of sorus 1.2–1.6 mm distant from pinna margin; indusia peltate, 1–1.2(–1.5) mm diam., membranous, brown, erose on margin.

Spore morphology. The spores of *Polystichum tiankengicola* are round in a polar view and elliptic in an equatorial view, with a spore size ca. 46.3×63.5 μm (polar axis \times equatorial axis). The ratio of the

length of the polar axis to that of the equatorial axis is ca. 0.73:1. The perispore sculpture is echinate with irregular ridges (Fig. 2E).

Distribution and ecology. *Polystichum tiankengicola* is known only from the type locality in the Luobu Stone Forest Sinkhole, in Hezhang County, northwestern Guizhou. Its unique habitat, being found at a sinkhole at high altitude (2530–2580 m) and in moist and low-light conditions in an area of karst topography, suggests that *P. tiankengicola* is likely endemic to this sinkhole. *Polystichum tiankengicola* grows in basic soil among limestone rubble or on limestone cliffs at the cave entrance at the bottom of a sinkhole, ca. 30 m below the ground surface. The type population extends from the bottom of the sinkhole to the cave entrance, an area of approximately 600 m². Associated ferns include *P. neolobatum* Nakai and *P. thomsonii* (Hook. f.) Bedd.

IUCN Red List category. Only one population with ca. 150 individuals was found at the type locality. *Polystichum tiankengicola* should clearly be classified as CR or Critically Endangered, according to the International Union for Conservation of Nature and Natural Resources guidelines (IUCN, 2008). Although the Luobu Stone Forest Sinkhole is not particularly a tourist attraction and is relatively inaccessible to typical visitors, the more adventurous do occasionally visit the bottom of the sinkhole in summer when precipitation is high, causing damage to the fragile habitats inside the sinkhole.

Etymology. The epithet of the new species is taken from the Chinese pinyin for “tiankeng,” meaning “sinkhole,” and the Latin suffix “-cola,” meaning “dweller,” referring to the species being a sinkhole dweller.

Discussion. *Polystichum tiankengicola*, with its small plants only to 22 cm tall and the proliferous bulbils on the rachis, is clearly a member of series *Basigemmifera* W. M. Chu & Z. R. He, currently within section *Micropolystichum* Daigobo. However, *P. tiankengicola* is unique in series *Basigemmifera* in having two bulbils, with one each found at the base and apex of the rachis. Morphologically, *P. tiankengicola* is most similar to *P. capillipes* in its small habit, another member of series *Basigemmifera*. Notably, *P. capillipes* has only one bulbil at the base of the rachis and it occurs in western China, including western Hubei and the Himalaya. The two species are potentially sympatric in northwestern Guizhou. In addition to the difference between the two species in the number of bulbils on the rachis,

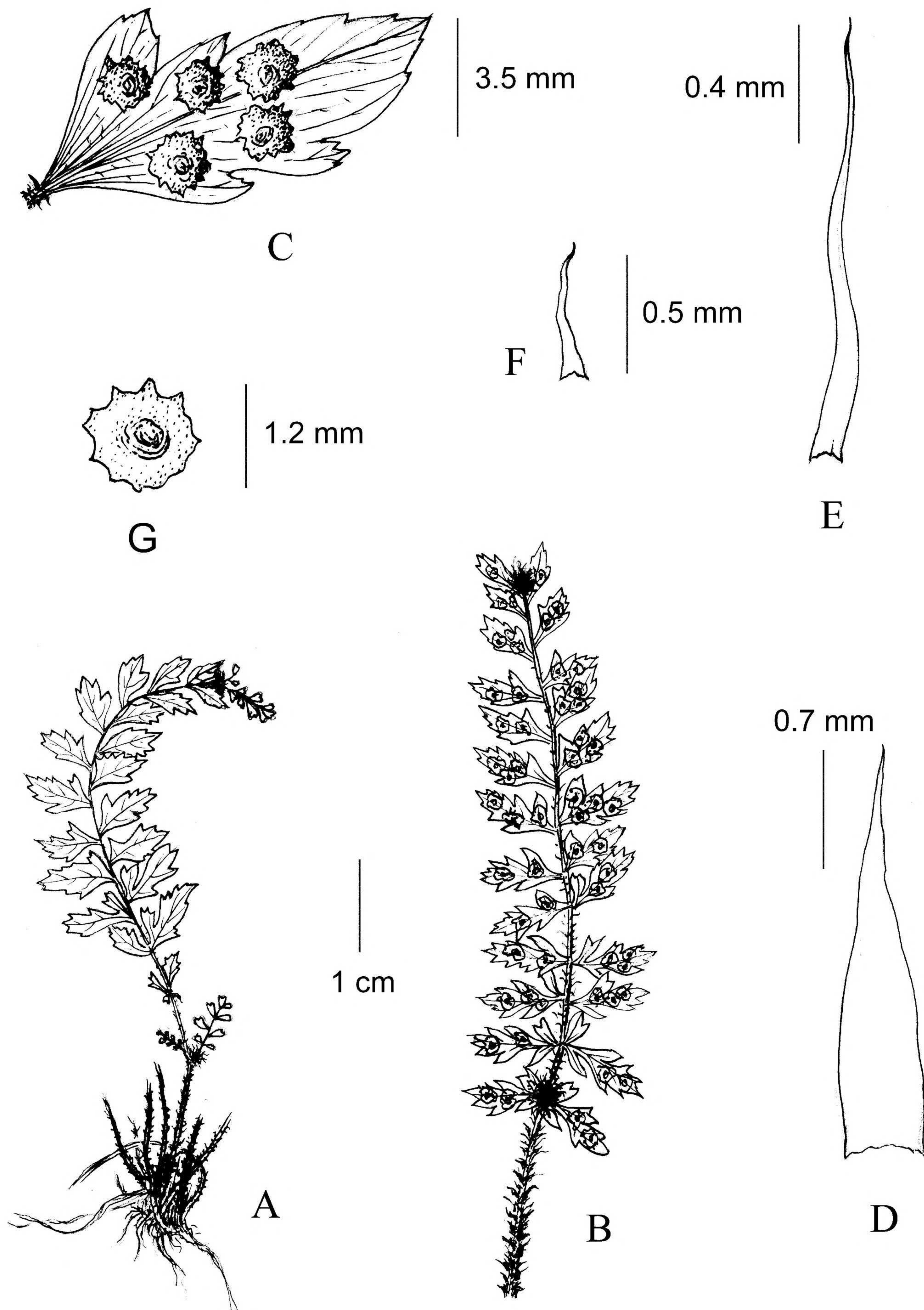


Figure 1. *Polystichum tiankengicola* Li Bing Zhang, Q. Luo & P. S. Wang. —A. Fertile plant habit. —B. Leaf, with bulbils evident at apex and base of lamina. —C. Pinna, abaxial surface. —D. Scale from base of petiole. —E. Rachis scale. —F. Microscale. —G. Indusium. A–G taken from the isotype Q. Luo 08380 (MO).

the leaves of *P. tiankengicola* have a truncate lamina apex, the pinna lobes are acute apically, and the pinnae are deltoid in shape in the lower portion of the leaf blade, but oblong above. The leaves of *P.*

capillipes have an acuminate lamina apex, the pinna lobes are acuminate apically, and the pinnae are oblong in the lower portion of the leaf blade. Palynologically, the perispores of *P. tiankengicola*

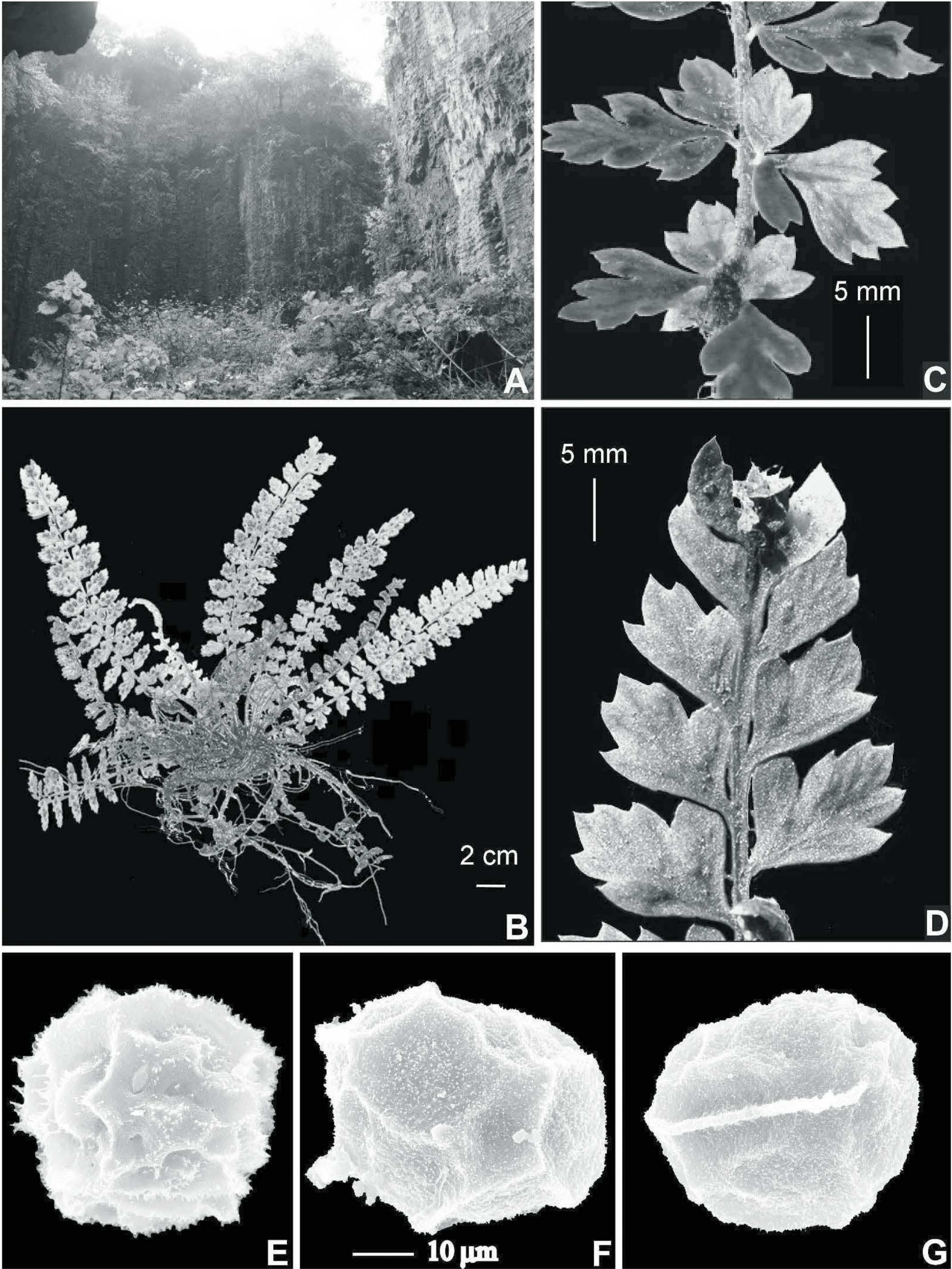


Figure 2. *Polystichum tiankengicola* Li Bing Zhang, Q. Luo & P. S. Wang. —A. The sinkhole and type locality for the new species *P. tiankengicola*. —B. Plant habit. —C. Lower portion of lamina, showing the basal bulbil on the rachis. —D. Upper portion of lamina, showing the apical bulbil on the rachis. —E. SEM micrograph of the spore of *P. tiankengicola* in polar view, taken from the paratype *Q. Luo 08353* (BJ). —F, G. SEM micrographs of the spores of *P. capillipes* (Baker) Diels in equatorial view. F is taken from *Qinghai-Xizang Expedition 11519* (PE) from Yanbian Co., Sichuan, China; G is taken from *Y.-T. Zhang & K.-Y. Lang 624* (PE) from Zhamo (Bomi) Co., Xizang (Tibet), China.

have an echinate sculpture, with numerous irregular ridges (Fig. 2E), while those of *P. capillipes* have a granulate sculpture (Fig. 2F, G), with only a few ridges. Notably, the perispore sculptures of *P. capillipes* were based on two samples from Sichuan and Tibet in China, respectively, and are consistent (Fig. 2F, G) with each other, but both differ from a previous report by Xiang (1992) in which *P. capillipes* was reported with a reticulate perispore sculpture. This implies that the currently circumscribed *P. capillipes* could be polyphyletic.

Only two species of *Polystichum* are known to consistently have two proliferous bulbils on the leaf rachis, *P. bigemmatum* Ching ex L. L. Xiang and *P. tiankengicola*. The former taxon has bipinnate leaves and both bulbils are located at the apex of the rachis (Kung et al., 2001), while the new species has pinnate leaves and the two bulbils are located at the base and apex, respectively, of the rachis. *Polystichum bigemmatum* is a member of section *Macropolystichum* Daigobo, following Kung et al. (2001), based on its bipinnate leaves and the presence of bulbils apically on the rachis.

The discovery of *Polystichum tiankengicola* in Jiucaiping is further evidence that this high-elevation sinkhole location is abundantly rich in fern diversity. The alpine vegetation, the variety of soils related to extraordinary limestone substrates, and the rarely disturbed habitats in Jiucaiping and neighboring regions certainly contribute to the evolution and preservation of this rich fern diversity.

Paratypes. China. **Guizhou:** Hezhang Co., Zhushi Yi Autonomous Xiang, Luobu Stone Forest Sinkhole, 2530–2560 m, 10 Oct. 2008, Q. Luo 08326a (BJ, HGAS, Herbarium Pei-Shan Wang [Guizhou Institute of Biology]), 2580 m, 10 Oct. 2008, Q. Luo 08353 (BJ, MO, Herbarium Pei-Shan Wang [Guizhou Institute of Biology]).

Acknowledgments. This project was partly supported by funding from the Guizhou Science and Technology Foundation (#2009–2092) and funding

from the Natural Science Foundation of the Department of Education of Guizhou Province (#20090065) to Q.L. We thank Pei-Shan Wang for his initial taxonomic identification and for kindly proposing the specific epithet, Hai He for providing an image of Figure 2, Bo Xu for help with SEM work, and Fa-Qiang Lü for preparing the illustration. Yun-Fei Deng, Victoria Hollowell, and an anonymous reviewer provided helpful comments. We thank the curators of the herbaria CDBI, HGAS, MO, and PE giving access to the material in their care, and we also thank collectors who provided material for use in this study.

Literature Cited

- IUCN. 2008. IUCN Red List Categories and Criteria, Version 7. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.
- Kung, H.-S., W.-M. Chu, Z.-R. He & L.-B. Zhang. 2001. *Polystichum* Roth. Pp. 1–246 in H. S. Kung (editor), Flora Reipublicae Popularis Sinicae, Vol. 5(2). Science Press, Beijing.
- Luo, Q. 2009. *Polystichum jiucaipingense*, a new species of Dryopteridaceae from Guizhou, China. Bull. Bot. Res. (Harbin) 29(2): 134–135.
- Wang, P.-S. & X.-Y. Wang. 1991. Study on pteridophytes of Guizhou (I). Guizhou Sci. 9: 227–231.
- Wang, P.-S. & X.-Y. Wang. 2001. *Polystichum* Roth. Pp. 517–552 in Pteridophyte Flora of Guizhou. Guizhou Science & Technology Press, Guiyang.
- Wang, X.-Y. & P.-S. Wang. 1994. Study on pteridophytes of Guizhou (II). Guizhou Sci. 12(2): 53–57.
- Wang, X.-Y. & P.-S. Wang. 1997a. A new species of *Cystopteris* (Athyriaceae) from Guizhou. Acta Bot. Yunnan. 19(2): 141–142.
- Wang, X.-Y. & P.-S. Wang. 1997b. New materials for *Polystichum* from Guizhou. Acta Bot. Yunnan. 19(1): 41–42.
- Xiang, L.-L. 1992. Studies on the spore morphology of the genus *Polystichum* from Yunnan. Yushania 9: 93–116.
- Zhang, L.-B., H. He & Q. Luo. 2010. *Polystichum puteicola*, sp. nov. (sect. *Haplopolystichum*, Dryopteridaceae) from a karst sinkhole in Guizhou, China, based on molecular, palynological, and morphological evidence. Bot. Stud. (Taipei) 51: 127–136.